REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
02-11-2008

2. REPORT TYPE
Progress Report

3. DATES COVERED *(From - To)*
July 24, 2007 - January 31, 2008

4. TITLE AND SUBTITLE
Physics and Cyber-Enabled Manufacturing Process Control

5a. CONTRACT NUMBER
N00014-07-1-1133

5b. GRANT NUMBER
N00014-07-1-1133

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
P.J. Casey, Cameron Booth, Dr. Joseph Beaman, Dr. Al Mok

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Texas at Austin
1 University Station C2200
Austin, TX 78712-0292

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
Ballston Centre Tower One
800 North Quincy Street
Arlington, VA 22217-5660

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
approved for public release

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The objective of the project is to be able to predict welding failures in real time and correct them as quickly as possible. This will be a drastic shift from the current statistically controlled manufacturing to dynamic model based manufacturing control.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
UU	UU	UU		3	Joseph Beaman
					19b. TELEPHONE NUMBER *(Include area code)* (512) 471-3058

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

N00014-07-1-1133 Progress Report
Physics and Cyber-Enabled Manufacturing Process Control

P.J. Casey, Cameron Booth, Dr. Joseph Beaman, Dr. Al Mok

The objective of the project is to be able to predict welding failures in real time and correct them as quickly as possible. This will be a drastic shift from the current statistically controlled manufacturing to dynamic model based manufacturing control.

In order to accomplish this goal we will choose a common welding defect. A model will be created to characterize what indicators in the system will be able to properly predict the formation of a defect. Experimental measurements and metallography will be used to try and validate the model. Once the model is proven to predict a failure in real time, controls can be implemented on the system. The end result will be using system controls to prevent defect formation.

A main challenge of the project is to choose a reliable but time efficient model that can accurately predict weld quality. This model will consist of a physically based set of stochastic differential equations that will be solved with Monte Carlo methods. Another difficult challenge will be collecting large amounts of sensor data, incorporating this data into the model and then predicting at faster than real time speeds. In order to mitigate uncertainty in the model it is crucial to acquire enough sensor data to be able to predict a defect with an acceptable probabilistic accuracy. Furthermore, the processing requirements will need to be optimized in order to reduce the time for data analysis. If this is not sufficient then the complexity of the models can be reduced to minimize the computation required. We are in the process of characterizing weld defects and models.

Co-PI Al Mok and graduate student Thomas Lauzon are currently conducting a review of available hardware design tools for implementing the Monte Carlo simulation by ASIC/FPGA. The plan is to first code up the simulation model using C. This will allow us to do the simulation and better understand the defect model calculation. The C code will also serve as the specification of for the hardware solution. The ASIC/FPGA design tools will be used to specify a prototype of the hardware solution that will then be simulated to get some initial performance results for comparison with the C solution. We shall experiment with different hardware architectural approaches to understand and evaluate the design tradeoffs. The hardware solution will be integrated with the rest of the controller design that will allow us to decide in real time when to stop the Monte Carlo defect simulation. Finally, we shall consider building a general design tool that will take as input any defect model in C code and output a ASIC/FPGA controller design that has real-time performance guarantees.

Thus far the main work has been to build a gas metal arc welding test station in order to collect data. The test station is now complete and ready to begin experimental testing. Further research has been done exploring modeling and control techniques that will be applicable to this process.

The future plan for this process will be to implement this procedure on other manufacturing techniques. Any product that is high value, low quantity and requires high reliability can implement this process and drastically increase the quality of the product with a much lower initial cost.

The relevance to the Navy is that they will be able to create high value products with the same reliability that comes from costly statistically based manufacturing. This will allow the Navy to design, build and test new technologies much faster than previously possible.

This technology has the potential to allow industry applications to produce high value products without running exhaustive tests. Industry will also be able to predict when a product is going to be out of specifications in real time. Real time alerts to defects will either be corrected by the controller or will alert the operator so the number of faulty products can be minimized.

In order to accomplish these goals we have established a relationship with another welding group at the University of Texas at Austin. This group is lead by Dr. Carolyn Seepersad, Dr. John Howell and Dr. Eric Taleff along with five other grad students. Los Alamos National Lab will also be collaborating as they investigate laser welding with similar experimental parameters. Constant communication between the two groups will ensure the continuity of the experiments. All of these groups are working together to accomplish mutual goals of welding and predictive process control.